⑲ 日本国特許庁 (JP)　　⑪特許出願公開

⑫ 公開特許公報 (A)　　昭56—28476

⑤Int. Cl.³	識別記号	庁内整理番号	
H 01 M 10/42		6338—5H	④公開 昭和56年(1981) 3月20日
G 01 R 31/36		7359—2C	発明の数 4
			審査請求 未請求

(全 10 頁)

⑤蓄電池の残存容量計

②特　　願 昭54—103182

②出　　願 昭54(1979) 8月14日

⑦発 明 者 [illegible]
東京都新宿区西新宿二丁目1番1号新神戸電機株式会社内

⑦発 明 者 山本博明
東京都新宿区西新宿二丁目1番1号新神戸電機株式会社内

⑦発 明 者 佐々木明男
東京都新宿区西新宿二丁目1番1号新神戸電機株式会社内

⑦発 明 者 和久井孝太郎
東京都世田谷区砧一丁目10番11号日本放送協会総合技術研究所内

⑦発 明 者 [illegible]
東京都世田谷区砧一丁目10番11号日本放送協会総合技術研究所内

⑦出 願 人 新神戸電機株式会社
東京都新宿区西新宿2丁目1番1号

最終頁に続く

明 細 書

1.発明の名称 蓄電池の残存容量計

2.特許請求の範囲

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

(15)

[illegible]

(16)

[illegible]

(17)

[illegible]

(18)

(19)

(20)

(21)

(22)

することもできる。

[illegible]

(27)

[illegible]

(28)

[illegible]

(29)

[illegible]

(30)

[illegible]

(31)

[illegible]

(32)

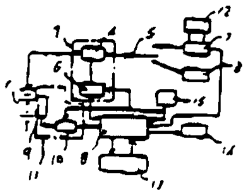
[illegible]

(33)

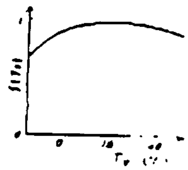
[illegible]

(34)

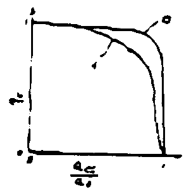
第1図



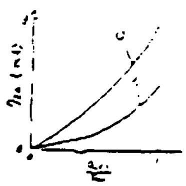
第2図



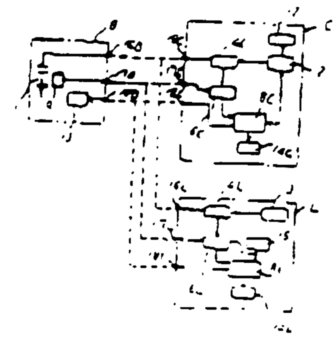
第3図



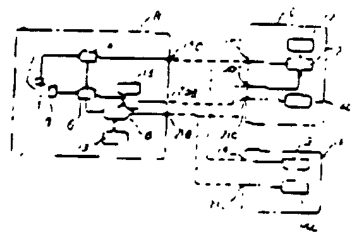
第4図



第5図



第6図



第1頁の続き

(72)発　明　者　大西和朗
東京都世田谷区砧一丁目10番11号日本放送協会総合技術研究所内
(72)発　明　者　川村剛
国分寺市東恋ケ窪一丁目280番地株式会社日立製作所中央研究所内
(72)発　明　者　野口浩
小平市御幸町32番地日立電子株式会社小金井工場内
(72)発　明　者　保ケ谷文雄
小平市御幸町32番地日立電子株式会社小金井工場内
(71)出　願　人　日本放送協会
東京都渋谷区神南二丁目2番1号
(71)出　願　人　株式会社日立製作所
東京都千代田区丸の内一丁目5番1号
(71)出　願　人　日立電子株式会社
東京都千代田区神田須田町1丁目23番2号

(19) Japanese Patent Office (JP)
(11) Japanese Patent Application Kokai Publication No.
(12) Publication of Unexamined Patent Application (A) Sho56-28476

(51) Int. CL3	Identification Symbol	JPO File Number
H 01 M 10/42		6338-5H
G 01 R 31/36		7359-2G

(43) Date of Publication of Unexamined Patent Application 1981 March 20
Number of Inventions 4
Request for Examination Not Submitted
(Total of 10 Pages in the Original Japanese)

(54) Storage battery residual capacity meter

(21) Patent application Filing No. Sho54-103382

(22) Application Filing Date 1979 August 14

(72) Inventor Kikuoka Takao
Within the Shin-Kobe Electric Machinery Co., Ltd. 2-1-1 Nishi-Shinjuku, Shinjuku-ku, Tokyo

(72) Inventor Yamamoto Hiroaki
Within the Shin-Kobe Electric Machinery Co., Ltd. 2-1-1 Nishi-Shinjuku, Shinjuku-ku, Tokyo

(72) Inventor Sasaki Noriyoshi
Within the Shin-Kobe Electric Machinery Co., Ltd. 2-1-1 Nishi-Shinjuku, Shinjuku-ku, Tokyo

(72) Inventor Wakui Kotaro
Within the Japan Broadcasting Corporation Comprehensive Technology Laboratory 1-10-11
Kinuta, Setagaya-ku, Tokyo

(72) Inventor Murakami Yoshinosuke
Within the Japan Broadcasting Corporation Comprehensive Technology Laboratory 1-10-11
Kinuta, Setagaya-ku, Tokyo

(71) Applicant Shin-Kobe Electric Machinery Co., Ltd. 2-1-1 Nishi-Shinjuku, Shinjuku-ku, Tokyo

Continued on last page

Specification

1. <u>Title of the Invention</u>:

Meter for Remaining Capacity in Storage Battery

2. <u>Claims</u>:

(1) A meter for remaining capacity in a storage battery comprising:

a quantity of electricity detecting portion for detecting a charged quantity of electricity and a discharged quantity of electricity in said storage battery so as to output the charged quantity of electricity and the discharged quantity of electricity as digital signals;

a temperature detecting portion for detecting the temperature of said storage battery so as to output the detected temperature as a digital signal;

a memory means that stores data and an equation required for calculating at least one of the quantities of either dischargeable electricity or time dischargeable by using the detected quantity of both the charged and discharged electricity and the detected temperature;

a digital calculation processing portion which calculates through digital calculation at least one of the quantity of dischargeable electricity and the time dischargeable by using a signal output from said quantity of electricity detecting portion and said temperature detecting portion, data stored in said memory means, and the equation; and

a display portion for displaying at least one of the dischargeable quantity of electricity and the dischargeable time.

(2) A meter for remaining capacity in a storage battery according to claim 1 wherein said temperature detecting portion comprises a temperature detector disposed in the vicinity of

said storage battery and an analog/digital converter for converting an output from the temperature detector into a digital quantity.

(3) A meter for remaining capacity in a storage battery according to claim 2 wherein said quantity of electricity detecting portion comprises a quantity of electricity detector for detecting the charged quantity of electricity and the discharged quantity of electricity by generally calculating both a charged current and a discharged current, and an analog/digital converter for converting an output from the quantity of electricity detector into a digital quantity.

(4) A meter for remaining capacity in a storage battery according to claim 3 wherein said temperature detector and said quantity of electricity detector operate at all times, and each of said analog/digital converters, said digital operation processing portion, and said memory portion operate intermittently.

(5) A meter for remaining capacity in a storage battery according to claim 2 wherein said quantity of electricity detecting portion comprises an amperage detector for detecting a charged amperage and a discharged amperage, an analog/digital converter for converting an output from the analog/digital converter into a digital quantity and a calculation means for time integrating the output from the analog/digital converter.

(6) A meter for remaining capacity in a storage battery according to claim 5 wherein said temperature detector and said current detector operate at all times, each of said analog/digital converters, said calculation means, said digital calculation processing portion, and said memory means operate intermittently.

(7) A meter for remaining capacity in a storage battery according to claim 6 wherein said digital calculation processing portion also serves as said calculation means.

(8) A meter for remaining capacity in a storage battery comprising:

a quantity of electricity detecting portion for detecting a charged quantity of electricity and a discharged quantity of electricity in said storage battery so as to output the charged quantity of electricity and the discharged quantity of electricity as digital signals;

a temperature detecting portion for detecting the temperature of said storage battery so as to output the detected temperature as a digital signal;

a storage battery capacity measuring portion for measuring the capacity of said storage battery by connecting a dummy load to said storage battery to discharge said storage battery;

a memory means that stores each kind of data, including a discharge capacity, at a standard temperature and an equation required for calculating at least one of either the quantity of

dischargeable electricity or time dischargeable at a detected temperature by using the detected quantity of both the charged and discharged electricity and the detected temperature;

a digital calculation processing portion for calculating out through digital calculation at least one of the quantity of dischargeable electricity and the dischargeable time by using a signal output from said quantity of electricity detecting portion and said temperature detecting portion, data stored in said memory means, and the equation; and

a display portion for displaying at least one of the dischargeable quantities of electricity and the time dischargeable;

wherein said digital operation processing portion calculates out the discharge capacity at the standard temperature by using the capacity of said storage battery detected in the measurement of the capacity by the storage battery capacity measuring portion, the signal output from said temperature

detector and the data stored in the circuit of said memory means so that the discharge capacity at the standard temperature is stored in said memory circuit as new data to compensate for any variation in the capacity resulting from the aging of said storage battery.

(9) A meter for remaining capacity in a storage battery according to claim 8 wherein said temperature detecting portion comprises a temperature detector disposed in the vicinity of said storage battery and an analog/digital converter for converting an output from the temperature detector into a digital quantity.

(10) A meter for remaining capacity in a storage battery according to claim 9 wherein said quantity of electricity detecting portion comprises a quantity of electricity detector for detecting the charged quantity of electricity and the discharged quantity of electricity by generally calculating both the charged current and the discharged current, and an analog/digital converter for converting an output from the

quantity of electricity detector into a digital quantity.

(11) A meter for remaining capacity in a storage battery according to claim 10 wherein said temperature detector and said quantity of electricity detector operate at all times, and each of said analog/digital converters, said digital calculation processing portion, and said memory portion operate intermittently.

(12) A meter for remaining capacity in a storage battery according to claim 11 wherein said quantity of electricity detecting portion comprises an amperage detector for detecting a charged amperage and a discharged amperage, an analog/digital converter for converting an output from the analog/digital converter into a digital quantity, and a calculation means for time integrating the output from the analog/digital converter.

(13) A meter for remaining capacity in a storage battery according to claim 12 wherein said

temperature detector and said current detector operate at all times, each of said analog/digital converters, said calculation means, said digital operation processing portion, and said memory means operate intermittently.

(14) A meter for remaining capacity in a storage battery according to claim 13 wherein said digital calculation processing portion also serves as said calculation means.

(15) A meter for remaining capacity in a storage battery comprising:

a quantity of electricity detecting portion for detecting a charged quantity of electricity and a discharged quantity of electricity in said storage battery so as to output the charged quantity of electricity and the discharged quantity of electricity as digital signals;

a temperature detecting portion for detecting the temperature of said storage battery so as to

output the detected temperature as a digital signal;

a portion for detecting the time which said storage battery is allowed to stand idle which totals such time and converts the total time into a digital signal;

a memory means that stores data and equations required for calculating at least one of the quantities of dischargeable electricity and time dischargeable by using the detected quantity of both the charged and discharged electricity and the detected temperature, as well as data, and the equations required for compensating for said dischargeable quantity of electricity and said time dischargeable by calculating the quantity of electricity self-discharged within said time during which said storage battery is allowed to stand idle;

a digital calculation processing portion for calculating out through digital calculation at least one of the quantities of dischargeable

electricity and the time dischargeable by using a signal output from said quantity of electricity detecting portion and said temperature detecting portion, data, and the equation stored in said memory means so as to compensate for variation in the discharge capacity resulting from said self discharge; and

a display means for displaying at least one of either said dischargeable quantity of electricity or said time dischargeable.

(16) A meter for remaining capacity in a storage battery according to claim 15 wherein said temperature detecting portion comprises a temperature detector disposed in the vicinity of said storage battery and an analog/digital converter for converting an output from the temperature detector into a digital quantity.

(17) A meter for remaining capacity in a storage battery according to claim 16 wherein said quantity of electricity detecting portion comprises a quantity of electricity detector for

detecting the charged quantity of electricity and the discharged quantity of electricity by generally calculating both a charged current and a discharged current, and an analog/digital converter for converting an output from the quantity of electricity detector into a digital quantity.

(18) A meter for remaining capacity in a storage battery according to claim 17 wherein said temperature detector and said quantity of electricity detector operate at all times, and each of said analog/digital converters, said digital calculation processing portion, and said memory portion operate intermittently.

(19) A meter for remaining capacity in a storage battery according to claim 18 wherein said quantity of electricity detecting portion comprises a current detector for detecting a charged current and a discharged current, an analog/digital converter for converting an output from the analog/digital converter into a digital quantity, and a calculation means for time

integrating the output from the analog/digital converter.

(20) A meter for remaining capacity in a storage battery according to claim 19 wherein said temperature detector, said current detector, and a portion for detecting the time during which said storage battery is allowed to stand idle operate at all times, and each of said analog/digital converters, said calculation means, said digital calculation processing portion, and said memory means operate intermittently.

(21) A meter for remaining capacity in a storage battery according to claim 19 or claim 20 wherein said digital calculation processing portion also serves as said calculation means.

(22) A meter for remaining capacity in a storage battery comprising:

a quantity of electricity detecting portion for detecting a charged quantity of electricity and a

discharged quantity of electricity in said storage battery so as to output the charged quantity of electricity and the discharged quantity of electricity as digital signals;

a temperature detecting portion for detecting the temperature of said storage battery so as to output the detected temperature as a digital signal;

a storage battery capacity measuring portion for measuring the capacity of said storage battery by connecting a dummy load to said storage battery so as to discharge said storage battery;

a portion for detecting the time which said storage battery is allowed to stand idle which totals such time and converts the total time into a digital signal;

a memory means that stores data and equations required for calculating at least one of the quantities of dischargeable electricity and time dischargeable by using the detected quantity of

both the charged and discharged electricity and the detected temperature, as well as data, and the equations required for compensating for said dischargeable quantity of electricity and said time dischargeable by calculating the quantity of electricity self-discharged within said time during which said storage battery is allowed to stand idle;

a digital calculation processing portion for calculating out through digital calculation at least one of the quantities of either dischargeable electricity and the time dischargeable by using a signal output from said quantity of electricity detecting portion and said temperature detecting portion, data, and the equation stored in said memory means so as to compensate for variation in the discharge capacity resulting from said self-discharge; and

a display means for displaying at least one of either said dischargeable quantity of electricity or said time dischargeable;

wherein said digital calculation processing portion calculates a discharge capacity at said standard temperature by using the capacity of said storage battery detected in the measurement of the capacity by the storage battery capacity measuring portion, the temperature detected by said temperature detector, and the data stored in the circuit of said memory means so that the discharge capacity at the standard temperature is stored in said memory circuit as new data so as to compensate for variation in the capacity resulting from the aging of said storage battery.

(23) A meter for remaining capacity in a storage battery according to claim 22 wherein said temperature detecting portion comprises a temperature detector disposed in the vicinity of said storage battery and an analog/digital converter for converting an output from the temperature detector into a digital quantity.

(24) A meter for remaining capacity in a storage battery according to claim 23 wherein said quantity of electricity detecting portion

comprises a quantity of electricity detector for detecting the charged quantity of electricity and the discharged quantity of electricity by generally calculating both a charged current and a discharged current, and an analog/digital converter for converting an output from the quantity of electricity detector into a digital quantity.

(25) A meter for remaining capacity in a storage battery according to claim 24 wherein said temperature detector and said quantity of electricity detector operate at all times, and each of said analog/digital converters, said digital calculation processing portion, and said memory portion operate intermittently.

(26) A meter for remaining capacity in a storage battery according to claim 25 wherein said quantity of electricity detecting portion comprises a current detector for detecting a charged current and a discharged current, an analog/digital converter for converting an output from the analog/digital converter into a digital

quantity, and a calculation means for time integrating the output from the analog/digital converter.

(27) A meter for remaining capacity in a storage battery according to claim 26 wherein said temperature detector, said current detector, and a portion for detecting the time which said storage battery is allowed to stand idle operate at all times, and each of said analog/digital converters, said calculation means, said digital calculation processing portion, and said memory means operate intermittently.

(28) A meter for remaining capacity in a storage battery according to claim 26 or claim 27 wherein said digital calculation processing portion also serves as said calculation means.

3. Detailed Description of the Invention:

The present invention relates to a meter for remaining capacity in a storage battery that displays the

remaining capacity and charge condition of the storage battery.

Storage batteries such as nickel cadmium storage batteries and lead batteries have quite recently come to be widely used as a power source for portable electric appliances. In any type of storage battery, the quantity of electricity that can be supplied through one charging is limited. When a load is driven by such batteries for a certain period of time, the battery requires charging. To improve the availability factor of an electric appliance, it is necessary to know how much electricity can be supplied to the storage batteries being discharged. One device that meets this purpose is the remaining capacity meter. The conventional type of meter for remaining capacity directly measures the quantity of charged and discharged electricity and displays the remaining capacity. In general, the remaining capacity is greatly affected by the temperature of the batteries and the charging efficiency. As a result, the accurate detection of remaining capacity is not possible by the simple measurement of the quantity of charged and discharged electricity, and it is necessary to

compensate for the affect of the temperature and the charging efficiency. However, because conventional remaining capacity meters perform this kind of compensation calculation by analog means their precision cannot be raised, and the remaining capacity cannot be accurately indicated. In addition, in order to determine the remaining capacity accurately it is necessary to compensate for the variation in the life of batteries and the variation in capacity resulting from self-discharge when they are allowed to stand idle. It was extremely difficult for analog remaining capacity meters to perform such compensation calculation.

The object of the present invention is to provide a remaining capacity meter in a storage battery which can accurately perform compensation calculation owing to the temperature of the battery, the charging efficiency, variation in the life the battery, and the self-discharge thereot and display the remaining capacity with high precision.

A meter for remaining capacity in accordance with the present invention will be detailed hereunder with reference to the embodiment shown in the drawings.

Figure 1 schematically shows an embodiment in which remaining capacity in a nickel cadmium storage battery is displayed. Referring to Figure 1, Reference Number 1 designates a nickel cadmium storage battery, 2 a charger for charging the storage battery, 3 a load (for example, a portable VTR and a TV camera) driven by the storage battery 1, 4 a quantity of electricity detector for showing a quantity of electricity by integrating charged and discharged current in the storage battery 1. In the embodiment shown in Figure 1, the charger 2 and the load 3 are connected to the storage battery via a shift-over switch 5 and the quantity of electricity detector 4. When the battery is charged, the charger 2 is connected to the battery 1 via the quantity of electricity detector 4. When the battery is loaded the load 3 is connected to the battery 1 via the electricity quantity detector 4.

The quantity of electricity detector 4 can comprise, for example, small resistors inserted in series into a

circuit through which charged and discharged current in the battery passes along with a potential memory device connected in parallel to the small resistors. The potential memory device outputs a voltage proportional to the quantity of electricity that passes through it. For example, a device known by the trade name "memoryode" manufactured by Sanyo Electric Co., Ltd., can be used as the potential memory device. As the above quantity of electricity device 4, a coulomb meter or the like can be used. An analog signal proportional to the quantity of charged and discharged electricity obtained by the quantity of electricity detector 4 is entered into an analog/digital converter 6 in which the analog signal is converted into a digital signal. The quantity of electricity detector 4 and the analog/digital converter 6 detect the quantity of charged electricity and the quantity of discharged electricity. Thus the quantity of electricity detector 4 and the analog/digital converter 6 constitutes a quantity of electricity detecting portion 7 that detects the quantity of charged electricity and the quantity of discharged electricity and outputs these quantities as digital signals. The digital signal given by the

converter 6 enters into a digital calculation processing portion 8.

To detect the temperature of the storage battery 1, a temperature detector 9 is disposed in the vicinity of the storage battery 1. The temperature detector used in the storage battery comprises, for example, a temperature detecting device that outputs a current proportional to the absolute temperature, the temperature detecting device having a resistance and a direct current power source connected in series to it, thereby making it possible to give across this resistance a voltage for temperature detection proportional to the absolute temperature. Such a temperature detecting device includes an AD 590 manufactured by Analog Devices, Inc. A temperature detecting signal given by the temperature detector 9 enters into an analog/digital converter 10 wherein the signal is converted into a digital signal. In this particular embodiment, the temperature detector 9 and the analog/digital converter 10 constitutes temperature detecting portion 11 which detects the temperature of the battery and converts the detected temperature into a digital signal. The digital signal given by the

converter 10 enters into the digital calculation processing portion 8.

Data designating the number of chargings enters from the charger 2 into the digital calculation processing portion 8. This data is used for determining the time when the variation in the life of the discharge capacity of the battery 1 is to be measured. To measure the variation in the life of the battery and heighten the precision in the calculation of the remaining capacity, a dummy load 12 is provided on the side of the charger 2. This dummy load 12 permits actual measurement of the discharge capacity of the storage battery. The dummy load 12 is connected to the storage battery each time a predetermined number of charging operations is performed. Consequently, the battery is discharged to the termination voltage via the dummy load 12 to allow the portion 7 for detecting the quantity of charged and discharged electricity to actually measure the discharge capacity. This data enters into the digital calculation processing portion 8.

A memory circuit 13 is mounted to store data and an equation required for calculations performed by the digital calculation processing portion 8. A display portion 14 is connected to the output end of the digital calculation processing portion 8. Only necessary results out of the results of the calculations performed by the digital calculation processing portion 8 are displayed on the display portion 14.

In the remaining capacity meter shown in Figure 1, the analog/digital converters 6 and 10, the digital operation processing portion 8, and the memory circuit 13 are driven by the storage battery 1. It is necessary to minimize the power consumed in the circuit of the remaining capacity meter and to relieve the load applied to the storage battery in order to supply sufficient power to the load 3. For this purpose, a timer 15 is mounted in the embodiment shown in Figure 1. Analog/digital converters 6 and 10, the digital calculation processing portion 8, and the memory circuit 13 are actuated with a signal transmitted from the timer at a certain interval, for example, once in every five minutes, so that these devices perform their

own predetermined calculation. After the predetermined calculations, power supply to each device is automatically cut off. On the other hand, when the battery 1 is allowed to stand idle without being connected to the load 3 or the charger 2, the timer 15 terminates the movement of the analog/digital converter 6 and the operation of the digital calculation processing portion 8. When the battery 1 is connected to the load 3 or the charger 2, the time which the battery is allowed to stand idle is integrated and entered into the calculation processing portion 8. In addition, when the battery 1 is allowed to stand idle, an instruction is given at a certain time interval to the temperature detector 11 in order to detect the temperature of the storage battery 1. The temperature thus detected is stored in the memory circuit 13. The time which the battery is allowed to stand idle and the temperature thereof during the time stored in the memory circuit 13 are used as data for compensating for the variation in the capacity owing to self-discharge. When the battery is connected to the load 3 or the charger 2, the digital calculation processing portion 8 performs an operation for compensating for the variation in the discharge capacity owing to the

self-discharge to calculate the remaining capacity or the like.

The digital calculation processing portion 8 calculates at least one of either the dischargeable quantity of electricity (remaining capacity) or time dischargeable. In addition, this portion also performs operations for calculating the charging state, the variation in the life of the battery at standard temperature, and compensating for the variation in remaining capacity owing to self-discharge. Data and equations required for performing these operations are stored in the memory circuit 13. The data and equation stored therein depend on the kind of battery and the parameter selection method. For example, in the case of a nickel cadmium storage battery, the following data is stored:

(I) The relationship between the battery temperature T_b[°C] and the ratio f (T) of the discharge capacity at the battery temperature during discharge against the discharge Q_r[Ah] at the standard temperature (hereinafter referred to as the standard discharge capacity)

(II) The relationship between the charging efficiency of the battery and the ratio Q_{cs}/Q_{o} of the battery temperature T_b and the charged state Q_{cs}[Ah] against the standard discharge capacity Q_o

(III) The relationship between the self-discharge current η_{SD}[mA] and the ratio of the battery temperature T_b and the charged state against the standard discharge capacity Q_o

The above data is to be determined in advance through testing or the like. An example of data (I), (II) and (III) is shown in Figure 2, Figure 3 and Figure 4 respectively.

Incidentally, referring to Figures 3 and 4, curves a and b designate cases where the battery temperature T_b stand idles at 0°C and 20°C, respectively.

As described above, in accordance with the present invention, the memory circuit stores all data used for the compensation. Even when the size of the battery or the load changes, the circuit itself need not be

modified unlike in the case of the conventional analog type. Only the data stored in the memory circuit 13 has to be modified.

The digital calculation processing portion 8 reads voltage values entered from the analog/digital converter 6. The quantity of discharged electricity Q_d that flows through the circuit during the reading time and the quantity of charged electricity Q_c are calculated from the difference between the voltage value read by the portion 8 and the value stored in the memory circuit 13 read by the same portion in the previous calculation and the proportional constant of the variation in the output voltage of the quantity of electricity detector 4 stored in advance in the memory circuit against the quantity of charged and discharged electricity. Then the following calculations are performed with the quantity of electricity Q_d and Q_c thus calculated, the temperature of the storage battery detected by the temperature detector 11, the charging time given by the charger 2, the measured time which the storage battery is allowed to stand idle, and the data stored in the memory circuit 13, the above time

being measured by the timer 15. The result of the calculations is displayed on the display portion 14.

(1) Calculation of Remaining Capacity

When the battery 1 is discharged with a load connected to it, the remaining capacity of the battery is calculated and displayed. A possible method for displaying the remaining capacity includes one for directly displaying the quantity of dischargeable electricity Q_r retained in the storage battery 1 and one for displaying the time dischargeable (time during which the battery can be discharged) as a load current. In accordance with the present invention, the remaining capacity can be displayed as either of the quantity of dischargeable electricity or time dischargeable. Otherwise, the remaining capacity can be displayed as both the quantity of dischargeable capacity and the time dischargeable. The quantity of dischargeable capacity Q_r is calculated based on the quantity of discharged electricity Q_d, the temperature T_b of the battery, and the data stored

in the memory circuit 13 through the following equation:

$$Q_r = Q_o \{f (T_b)-1\} + Q_{cs} - \Sigma Q_d \quad \text{---} \ (1)$$

wherein Q_o designates the standard discharge capacity, Q_{cs}, the charged state at the termination of the previous charging operation (the calculation of the charged state will be detailed hereinafter), and ΣQ_d the total quantity of discharge after the initiation of the present charge. In addition, an example of the function f (T_b) is shown in Figure 2. Incidentally, the time dischargeable can be obtained by dividing the above quantity of dischargeable electricity Q_r[Ah] by the discharged current. Either one or both of the quantity of dischargeable electricity and the dischargeable time is displayed on the display portion 14.

(2) Calculation of the Charged State Q_{cc}

The charged state of electricity (the quantity of electricity charged in the storage battery) is calculated based on the quantity of charged electricity Q_c, the temperature T_b of the battery, the charging time t_k required up to the number of times k for reading data, and the data stored in the memory circuit 13 in the following equation:

$$Q_{cs}(t_k) = Q_{cs}(t_{k-1}) - \eta_c(T_b, \frac{Q_{cs}(t_{k-1})}{Q_o}) \cdot Q_c \quad \text{---} \quad (2)$$

wherein Q_{cs} designates the charged state at k number of times of reading data. The time of the initiation of the charging is represented by the following equation:

$$Q_{cs}(t_o) = Q_{cs} - \Sigma Q_d \quad \text{---} \quad (3)$$

Incidentally, an example of the function η_c (T_b, $Q_{cs}(t_{k-1})/Q_o$) is shown in Figure 3.

The above charged state is calculated in every definite time determined by the timer 15. The result of the calculation is displayed on the display portion 14. Thus such a display of the charged state simultaneously provides the process of the charging when a plurality of storage batteries so as to make it possible to easily predict the time when the charging process is completed. This facilitates the usage schedule of the storage battery. Although, the calculation of the charged state is absolutely required, the display thereof is not necessarily needed.

Upon completion of the charging of the storage battery 1, the charged state Q_{cd} at that time is compared with the standard discharge capacity Q_o. A smaller value is stored in the memory circuit 13 as $Q_{cd'}$.

(3) Calculation for Compensating for Variation in the Capacity Owing to the Self-Discharge of the Storage Battery

The storage battery 1 self-discharges to some degree when no electricity is supplied to a load. Thus correct calculation of the remaining capacity requires the calculation of the loss of electricity owing to self-discharge so as to compensate for such loss. In the present invention, when a storage battery is allowed to stand idle, the charged state after the compensation of the loss of electricity owing to self-discharge is calculated at the initiation of the discharge based on the battery temperature T_b, the time t_i which the battery is allowed to stand idle until the number of time i for reading data, and the data stored in the memory circuit 13 using the following equation:

$$Q_{cc}(t_i) = Q_{cs}(t_{i-1}) - \eta_{sv}\left(\frac{Q_{cs}(t_{i-1})}{Q_c}\right) \cdot (t_i - t_{i-1}) \quad --- (4)$$

wherein $Q_{ca}(t_i)$ designates the charged state in the case of data reading circuit i. An example of the function $\eta_{gD}(T_b, Q_{ca}(t_{i-1})/Q_{a})$ is shown in Figure 4. The charged state at the initiation of the discharge is designated by

$$Q_{ca}(T_a) = Q_{ac} - \Sigma Q_d \quad --- (5)$$

The quantity of dischargeable electricity is calculated with the charge Q_{ca} represented by Q_{ca}.

(4) Calculation for Compensating for Variation in the Capacity Owing to the Change in the Life of the Storage Battery

In general, storage batteries gradually decrease in capacity along with increase in the number of the discharge cycles. Storage batteries are normally replaced by a new one when the capacity decreases to less than 50% in most cases. Thus the capacity of the storage battery changes during its life. Thus, when the standard discharge capacity Q_c is kept at a preset level, the

remaining capacity thus calculated generates a large error. The following method is available for approximating the standard discharge capacity with regard to the capacity of the storage battery at that point.

(a) The standard discharge capacity is compensated for during calculation by determining and storing in advance in the memory circuit 13 the relationship between the deterioration in the life of the storage battery and the period of usage, the number of charging and discharging cycle, the integrated quantity of discharged electricity, and the integrated quantity of stored electricity.

(b) After the storage battery is completely charged, the storage battery is actually discharged to measure the capacity of the storage battery. The measured value is compensated for in terms of temperature, and

the measured value is used as the standard discharge capacity Q_0.

In the present invention, any of those methods can be used. In the embodiment shown in Figure 1, compensation for life is carried out with the method (b). Consequently, in the embodiment shown in Figure 1, a dummy load 12 is provided on the side of the charger 2. After the storage battery is completely charged, the dummy load 12 is connected to the storage battery 1. The quantity of the discharged electricity is thus detected, and the capacity of the storage battery is actually measured. In this case, two methods can be considered as means for determining the capacity of the storage battery. In one method, the capacity of the storage battery is determined from the relationship between the capacity of the storage battery and the discharge voltage measured and determined in advance by allowing the storage battery 1 to momentarily discharge. In the other method, the capacity of the storage battery is actually measured by allowing the storage battery

to completely discharge to termination voltage. In the case of nickel cadmium storage batteries, the variation in the discharge voltage is small. It is also very difficult to measure the capacity of the storage battery. In this embodiment, the method of discharging the battery to the termination voltage is adopted. An actual measurement of the capacity of the storage battery is performed once when a predetermined number of charging operations (for example thirty times) is performed. After the discharge capacity is measured, the storage battery is recharged. The number of charging operations is counted with a counter incorporated into the charger 2. When the number of charging operations reaches a predetermined umber, a signal is transmitted to a digital calculation processing portion 8 to indicate the time has come for the capacity of the storage battery to be measured. Upon receiving the signal, the digital calculation processing portion 8 offers to the charger 2 an instruction to perform a charging and discharging pattern in a cycle of measuring the capacity of the storage battery, the pattern includes the following steps;

charging, complete discharging to the termination voltage, and the calculation of function $f(T_b)$ of the standard temperature Q_o. The value of the standard discharge capacity Q_o thus calculated is used as a standard discharge capacity for a predetermined number (for example 30 times) of charging and discharging cycles. Incidentally, compensation for the discharge capacity may be performed every time the battery is charged. But it is sufficient if such compensation is made at the predetermined charging times.

As discussed above, in the present invention, the standard charging capacity is compensated for depending on the number of charging and discharging cycles. Thus it is possible to accurately detect the remaining capacity even when the life of the battery is about to expire. It is also possible to accurately detect the actual capacity of the battery. Thus it is possible, when necessary, to display the change in the life of the battery in terms of the ratio of the capacity of the battery to the rated capacity. When the capacity of the battery has decreased to less than a level of

the usage limit, a warning can be provided by means of a red lamp or the like.

In the above embodiment, the quantity of electricity detector 4, which generates an output signal proportional to the quantity of electricity, detects the quantity of the charged and discharged electricity. In another method, an amperage detector (for example small resistors inserted in series into a charged circuit through which charging and discharging current passes) may be used to detect the charging and discharging current, which enters into the digital calculation processing circuit 8, in which the charging and discharging current is time integrated. In this time integration process, the analog/digital converter 6 and the digital calculation processing portion 8 are intermittently operated by the timer 15. The current value measured in a certain time interval (for example 5 minutes) is used in the above time integration to detect the quantity of electricity over a period when the current value is not actually measured on the assumption that current flows uniformly even when such measurement is not carried out. When the variation in the load is small, the quantity of discharged

electricity can be calculated without fail even by such a method. Such a method even reduces the power consumed in the circuit of the remaining capacity meter.

In order to embody the construction illustrated in the block diagram shown in Figure 1, such devices, for example, as the portion 7 for detecting the quantity of charged and discharged electricity, the temperature detector 11, the digital calculation processing portion 8, the memory circuit 13, and the display unit 14 are incorporated into a unit to be attached to the storage battery 1 as accessories. When the storage battery 1 is connected to the charger 2, the charger 2 may be connected to the digital calculation processing portion 8 or the like so that a necessary signal is exchanged between them. In addition, when the load 3 (for example, a portable VTR and TV camera) can be provided with a terminal to which the charger is connected so that the storage battery 1 may be charged with the portion, mounted within the load 3 except the charging device 2 or when the charger 2 can be mounted within the load 3, all portions of the construction shown in Figure 1 can be incorporated into the load 3. With

respect to devices like the analog/digital converters 6 and 10 that can be either used inside or outside the load, the whole unit can be constructed so that the analog/digital converters 6 and 10 can be mounted either inside or outside the load 3.

In addition, each part of the construction shown in Figure 1 can be arranged separately such as, for example, a storage battery, a charger, and a load. Figure 5 is an embodiment in which each part is arranged separately. Referring to Figure 5, Symbols B, C, and L designate a unit arranged on the side of the storage battery 1, a unit arranged on the side of the charger, and a unit arranged on the side of the load, respectively. In other words, in this particular embodiment, a temperature detector 9 and a memory circuit 13 are mounted on the side of the storage battery 1 so that the detector 9 and the circuit 13 are integrated in the storage battery 1. On the side of the charger 2 are mounted a quantity of electricity detector 4C, an analog/digital converter 6L, a digital calculation processing portion 8, a display portion 14, and a dummy load 12, the quantity of electricity detector 4C detecting only the quantity of charged

electricity. On the side of the load 3 are mounted a quantity of electricity detector 4L, an analog/digital converter 6L, the digital calculation processing portion 8, the display portion 14 and a timer 15, the quantity of electricity detector 4C detecting only the quantity of discharged electricity. Here, the analog/digital converters 6C and 6L also serve as converters for converting an output signal from the temperature detector 9. Each analog/digital converter 6C and 6L alternately performs the digital conversion of a detected signal of the temperature and a digital conversion of the quantity of electricity. Since the charger 2 is connected to a commercial power source, no timer is mounted on the side of the charger. Since the memory circuit 13 is required to store common data between the calculation upon charging and the calculation upon discharging. In this particular embodiment, a timer 15 is mounted on one storage battery.

In accordance with the construction shown in Figure 5, when the battery is charged, terminals 16B, 17B, and 18B on unit B on the side of the storage battery each connecting to the storage battery 1, the temperature

detector 9, and the memory circuit 13 are connected to terminals 16C, 17C, and 18C, respectively, each one connected to the quantity of electricity detector 4C, the analog/digital converter 5C, and the digital calculation processing portion 8C in the unit C on the side of the charger. Furthermore, when the storage battery 1 is used by mounting it on the load 3, terminals 16B, 17B, and 18B of unit B on the side of the storage battery are connected to terminals 16L, 17L, and 18L, respectively, each one connected to the quantity of electricity detector 4L, the analog/digital converter 6L and the digital calculation processing portion 8L. In such a case, the display portion displays at least one of either the quantities of dischargeable electricity or time dischargeable.

Figure 6 is another embodiment in which each part shown in Figure 1 is separately arranged. In this particular embodiment, unit B on the side of the charger is provided with the quantity of electricity detector 4 for detecting both charging and discharging current, the analog/digital converter 6, the digital calculation processing portion 8, the temperature detector 6, the memory circuit 13, and the timer 15. Unit C is

provided with the dummy load 12 and the display portion 14 in addition to the charger 12. Furthermore, the unit L on the side of the load is provided with the load 3 and the display portion 14L.

In accordance with the construction shown in Figure 5, when the battery is charged, a terminal connected to the quantity of electricity detector 4 in unit B, a terminal 20B (at least one terminal that receives a signal designating the number of charging operations and outputs an instruction signal to the charger) connected to the charger 2 in the digital calculation processing portion 8, and an output terminal 21B of the digital calculation processing portion 8 are connected to a charging output terminal 19C of the charger 2 in unit C on the side of the charger, a terminal 20C (at least one terminal connected to the digital calculation processing portion 8 of the charger 2, and a terminal 21C connected to the display portion 14C, respectively. In addition, when the storage battery is mounted in the load, the above terminals 19B and 21B are connected to a terminal 19L connecting to the load 3 in unit L on the Load side and a terminal 21L connecting to the display portion 14L, respectively.

In addition to the construction shown in Figure 5 and Figure 6, the storage battery and the load are combined so as to constitute one unit while another unit is constituted on the charger. Thus, the whole construction can be divided into two units. The load and the charger are combined into one unit while the storage battery is constituted into another unit. Thus, the whole construction can be divided into two portions. In the present invention, the construction of the minute parts is arbitrary.

In the above embodiments, the analog/digital converters, the digital calculation processing portion, and the memory circuit are operated intermittently with a timer. When the capacity of the storage battery is larger than required, they can be operated consecutively.

As discussed above, the present invention performs calculations for compensation through the digital calculation processing so that remaining capacity can be accurately determined with good precision through the performance of complex calculation processing. Therefore the present invention has an advantage in

precision in that the indication of the remaining capacity can be improved. In particular, the present invention claimed in claim 8 or claim 15 is capable of compensating for the change in the life of the storage battery or the variation in capacity owing to self-discharge when the battery is mounted. An analog-type meter for the remaining battery finds it very hard to perform such compensation. Furthermore, the present invention claimed in claim 22 is capable of compensating for both the change in the life of the storage battery or the variation in the capacity owing to self-discharge when the battery is mounted. This notably improves the precision in the indication of the remaining capacity.

4. Brief Description of the Drawings:

Figure 1 is a block diagram showing a basic construction in one embodiment according to the present invention;

Figure.2 is a diagram showing one example of the properties of the ratio of the discharge capacity to

the standard capacity ratio at the time of the discharge with regard to the battery temperature;

Figure 3 is a diagram showing one example of the properties of the charging efficiency with regard to the charged state represented as a temperature parameter of the battery;

Figure 4 is a diagram showing the properties of the self-discharge current when the battery is allowed to stand idle with regard to the charged state represented as a parameter of the battery temperature; and

Figures 5 and 6 are block charts showing other different embodiments in accordance with the present invention.

1 ... storage battery, 2 ... charger, 3 ... load, 4, 4C, 4L ... quantity of electricity detector, 6 ... analog/digital converter, 7 ... quantity of electricity detecting portion, 8, 8C, 8L ... digital calculation processing portion, 9 ... temperature detector, 10 ... analog/digital converter, 11 ... temperature detector,

12 ... dummy load, 13 ... memory circuit, 14 ... display portion